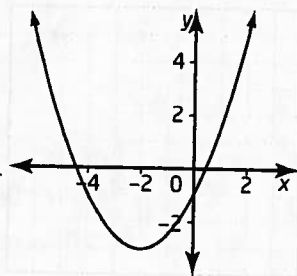


Communicate Your Understanding

- C1** Why is the vertical line through the vertex called the axis of symmetry? Illustrate with an example.
- C2** When describing the transformation from $y = x^2$ to $y = 2x^2$, you say that it has been stretched vertically by a factor of 2, instead of compressed horizontally. Explain why vertical stretches are used in descriptions.

- C3** Which equation is correct for the graph shown? Explain your reasoning.

- A** $y = (x + 2)^2 - 3$
- B** $y = \frac{1}{3}(x + 2)^2 - 3$
- C** $y = \frac{1}{2}(x + 2)^2 - 3$
- D** $y = -2(x + 2)^2 - 3$



Practise

For help with questions 1 and 2, see Example 1.

1. Copy and complete the table for each parabola. Replace the heading for the second column with the equation for the parabola.

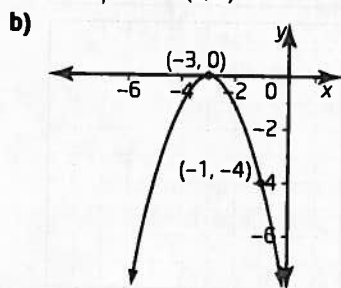
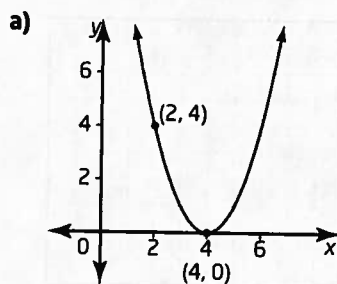
| Property | $y = a(x - h)^2 + k$ |
|---|----------------------|
| Vertex | |
| Axis of symmetry | |
| Stretch or compression factor relative to $y = x^2$ | |
| Direction of opening | |
| Values x may take | |
| Values y may take | |

- a)** $y = (x - 4)^2$
- b)** $y = (x - 2)^2 - 4$
- c)** $y = (x + 3)^2 - 2$
- d)** $y = \frac{1}{2}(x + 1)^2 + 5$
- e)** $y = (x - 7)^2 - 3$
- f)** $y = -(x - 1)^2 + 7$
- g)** $y = 2(x - 4)^2 - 5$
- h)** $y = -3(x + 4)^2 - 2$

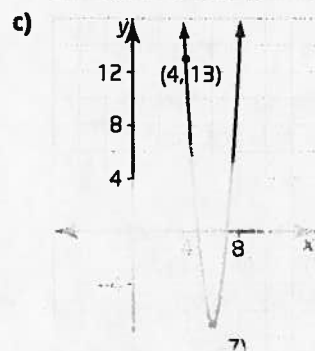
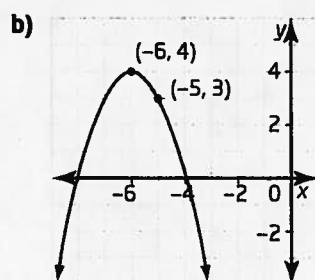
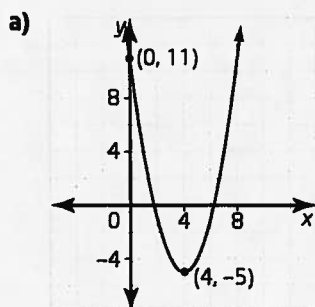
2. Sketch each parabola in question 1.

For help with questions 3 to 7, see Example 2.

3. Write an equation for the parabola with vertex at $(2, 3)$, opening upward, and with no vertical stretch.
4. Write an equation for the parabola with vertex at $(-3, 0)$, opening downward, and with a vertical stretch of factor 2.
5. Write an equation for the parabola with vertex at $(4, -1)$, opening upward, and with a vertical compression of factor 0.3.
6. Write an equation for each parabola.



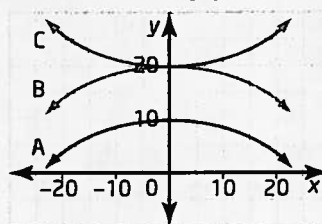
7. Write an equation for each parabola.



Connect and Apply

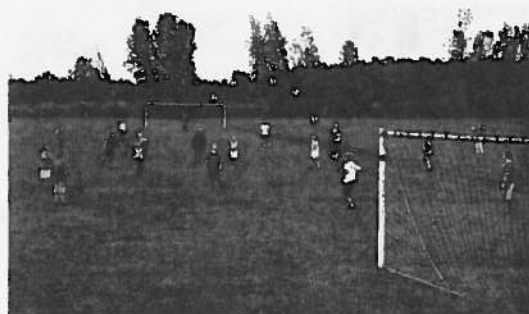
8. The graph of $y = x^2$ is stretched vertically by a factor of 3 and then translated 2 units to the left and 1 unit down. Sketch the parabola and write its equation.
9. The graph of $y = x^2$ is reflected in the x-axis, compressed vertically by a factor of $\frac{1}{2}$, and then translated 2 units upward. Sketch the parabola and write its equation.
10. a) Find an equation for the parabola with vertex (1, 4) that passes through the point (3, 8).
b) Find an equation for the parabola with vertex (-2, 5) and y-intercept 1.

11. A stadium roof has a cross section in the shape of a parabolic arch with equation $y = -\frac{1}{45}x^2 + 20$. Which graph represents the arch? Justify your reasoning.



For help with questions 12 and 13, see Example 3.

12. The path of a soccer ball is modelled by the relation $h = -\frac{1}{16}(d - 28)^2 + 49$, where d is the horizontal distance, in metres, after it was kicked, and h is the height, in metres, above the ground.



- a) Sketch the path of the soccer ball.
- b) What is the maximum height of the ball?
- c) What is the horizontal distance when this occurs?
- d) What is the height of the ball at a horizontal distance of 20 m?
- e) Find another horizontal distance where the height is the same as in part d).